

# DESCRIPTION OF A LAND CLASSIFICATION SYSTEM AND ITS APPLICATION TO THE MANAGEMENT OF TENNESSEE'S STATE FORESTS

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**Abstract**—The Tennessee Division of Forestry has adopted a land classification system developed by the senior author as the basic theme of information for the management of its 15 state forests (162,371 acres) with at least 1 in each of 8 physiographic provinces. This paper summarizes the application of the system to six forests on the Cumberland Plateau. Landtypes are the most detailed level in the hierarchical system and represent distinct units of the landscape (mapped at a scale of 1:24,000) as defined by physiography, climate, geology, soils, topography, and vegetation. Each of the 39 landtypes are described in terms of geographic setting, dominant soils, parent material, depth to bedrock, soil texture, soil drainage, relative soil water supply, relative fertility, and forest type. Additional information includes species suitable, site productivity, and operability for management activities. The maps aid the delineation of stands, streamside management zones, and “conservation” and other special use areas; the location of rare, threaten and endangered (RTE) species; the design of harvests; and the modeling of future forest conditions. The landtypes are an integral element in modeling wildlife habitat, in siting game food plots, and planning other wildlife management activities, particularly on forests that are dual wildlife and forest management areas. The maps are excellent training devices and extremely useful in explaining management plans to legislators and the public.

## INTRODUCTION

The Tennessee Division of Forestry (TDF) has adopted a land classification system developed by the senior author (Smalley 1991a) as the basic theme of information for the management of its 15 state forests (SFs). At least one SF occurs in each of eight physiographic provinces—Southern Appalachian Mountains, Ridge and Valley, Cumberland Plateau, Eastern Highland Rim, Nashville Basin, Western Highland Rim, Upper Coastal Plain, and Mississippi River Embayment. In this paper we describe the system, how it has been modified and expanded from the original regional guides, and how it is being applied in the management of six state forests on the Cumberland Plateau and in the Cumberland Mountains.

## THE LAND CLASSIFICATION SYSTEM

In the mid 1980s, Smalley (1986b) developed a land classification system for the 29 million acres of the Cumberland Plateau and Highland Rim/Pennyroyal physiographic provinces in parts of Alabama, Georgia, Tennessee, Kentucky, and Virginia. The system, which was adapted from Wertz and Arnold's (1975) Land System Inventory, can best be described as a process of successive stratifications of the landscape. Stratifications are based on the interactions among and controlling influences of ecosystem components—physiography, climate, geology, soils, topography, and vegetation. Macroclimate does not vary much across the two physiographic provinces, but microclimate varies because of local relief. This experience reinforced Rowe's (1996) maxim “...that every part of the terrain has to be confronted; there is no avoiding those in-between and odd ball units...”. Since the current species composition and structure of Rim and Plateau forests was more a function of repeated disturbances than an indication of succession and site potential, vegetation was relegated to a minor role in the development of the land classification system. Application of the system to other physiographic provinces represents an extension of the original concept (Smalley 1991b).

The five levels of Smalley's system proceeding from the least-detailed to the most-detailed are: physiographic province, region, subregion, landtype association, and landtype. These five levels approximate the lower five levels of the National Hierarchical Framework of Ecological Units (NHFEU) (Avers and others 1993) that is also known as the Bailey-Forest Service classification (Bailey 2002). In Smalley's hierarchical system, landtypes are the most detailed level. They represent distinct units of the landscape and are mapped at a scale of 1:24,000. To date, nearly 750,000 acres of state forest, state wildlife management areas, and private and forest industry lands have been mapped with the system.

Compared with the NHFEU (Bailey and others 1994, McNab and Avers 1994), Smalley's (1982, 1986a) combined Mid- and Northern Cumberland Plateau regions are equivalent to the Northern Cumberland Plateau section (221H), his Southern Cumberland Plateau region (Smalley 1979) is equivalent to the Southern Cumberland Plateau section (231C), and his Cumberland Mountain region (Smalley 1984) is equivalent to the Southern Cumberland Mountains Section (221I).

## SELECTED STATE FORESTS

This system was applied to six SFs (proceeding south to north) – Franklin (FSF), Prentice Cooper (PCSF), Bledsoe (BSF), Lone Mountain (LMSF), Scott (SSF), and Pickett (PSF) (fig. 1). Four are in the Mid-Cumberland Plateau region (Smalley 1982); Lone Mountain is located at the junction of the Mid-Cumberland Plateau and the Cumberland Mountain regions (Smalley 1984). Pickett is located at the extreme southern end of the Northern Cumberland Plateau region (Smalley 1986a). Pickett SF surrounds Pickett State Park administered by the Department of Conservation and Environment. Prentice Cooper SF is also a wildlife management area, administered by the Tennessee Wildlife Resources Agency under a cooperative agreement. Scott SF borders the Big South Fork National River and Recreation Area administered

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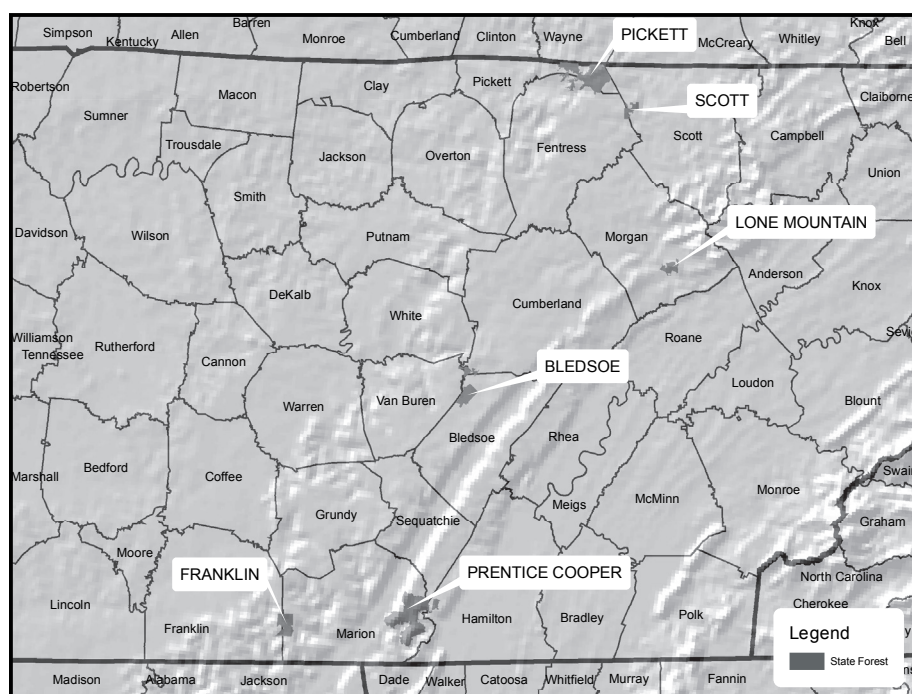


Figure 1—Locations of state forests on the Cumberland Plateau of Tennessee.

by the U.S. Park Service. When these forests were acquired, they were in old fields or pastures, cut-over, or abused as a result of poor farming practices, surface mining, or high-grade logging.

## LANDTYPES

Based on experience, some of the original landtypes were combined, others were divided into two or more landtypes, and some new ones were described. Altogether, 39 distinct landtypes were identified on the 6 SFs. The occurrence of landtypes on each SF, their general topographic location, and their relation to the original regional guides are shown in table 1.

## CHARACTERISTICS OF THE CUMBERLAND PLATEAU/CUMBERLAND MOUNTAINS

### Geology

The Cumberland Plateau is underlain by nearly level Pennsylvanian strata dominated by sandstones along with siltstones, shales, and coal (Swingle and others 1966) (fig. 2). Usually the Warren Point sandstone forms the escarpment (free-face) of the Plateau. Lone Mountain SF rises above the top of the Plateau and is underlain with three younger shale-dominated Pennsylvanian strata. Below the Pennsylvanian rocks are older Mississippian strata dominated by limestone and dolomite with some siltstone, shale, and thin strata of sandstone. Most of these Mississippian rocks are covered with colluvium. The Monteagle limestone is exposed only on the lower slopes of the Plateau escarpment and in river gorges (BSF). Below the Monteagle are the St. Louis and Warsaw limestones which form the rolling surface of the Eastern Highland Rim to the west of the Cumberland Plateau. These older Mississippian rocks plus Silurian and Ordovician strata are exposed along the margins of the Sequatchie Valley anticline west of PCSF

and along the Plateau escarpment facing east into the Ridge and Valley province.

### Soils

As expected, general soil associations delineated at a scale of 1:750,000 (Springer and Elder 1980) show a strong correlation to major topographic features and are equivalent to the landtype association level in the hierarchy. Also, greater interest in forested landscapes by the National Resource Conservation Service has resulted in more detailed and useful soil surveys of Plateau counties, e.g., Bledsoe (Davis 1993), Grundy (Prater 2001), Pickett, and Fentress (Campbell and Newton 1995).

Residual soils common to the Plateau surface and the crest and upper slopes of Lone Mountain are mostly siliceous and mesic Ultisols and Inceptisols. Textural class varies from fine-loamy to coarse-loamy and loamy skeletal. Deep colluvial soils common to the upper escarpment slopes of the Plateau and lower slopes of Lone Mountain are siliceous and mesic Ultisols with high coarse fragment content. Mixed, thermic Alfisols and occasionally Mollisols formed in the exposed Mississippian limestone on the lower sides of the Plateau. These soils are shallow to deep with loamy skeletal texture.

### Topography

The Plateau surface is weakly to moderately dissected with undulating to rolling topography. Elevation of the surface is highest (1,660 to 1,700 feet) on FSF and PCSF and decreases northward to 1,300 to 1,400 feet on LMSF before rising slightly near the Tennessee-Kentucky State line on PSF to 1,500 to 1,600 feet. Local relief on the surface is 100 to 200 feet. Most streams are intermittent and flow in U- or broad V-shaped valleys. The stream channels become narrow V-shaped and rock-strewn near the escarpment. When flowing, these streams plunge over the nearly vertical sandstone

**Table 1—Unified landtype numbering system for the Cumberland Plateau**

Landtype name	Original guide number	Unified LT number	State Forests					
			Franklin	Prentice Cooper	Bledsoe	Scott	Lone Mountain	Pickett
----- Landtypes above the escarpment -----								
<b>From Mid-Cumberland Plateau Guide (Smalley 1982)</b>								
Undulating sandstone uplands	1	1	1	1	1	1	1	1
Broad sandstone ridges and convex upper slopes	2	2	2	2	2	2	2	2
Narrow sandstone ridges and convex upper slopes	4	4	4	4	4	4	4	4
North sandstone slopes	5	5	5	5	5	5	5	5
South sandstone slopes	6	6	6	6	6	6	6	6
Shallow soils and sandstone outcrops above the escarpment	7	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Footslopes, terraces, streambottoms w/good drainage - above the escarpment	14	14.1	14.1	14.1	14.1	14.1	14.1	14.1
Terraces, streambottoms w/poor drainage - above the escarpment	15	15.1	15.1		15.1			
<b>From Cumberland Mountain Guide (Smalley 1984)</b>								
Surface mines - orphan	26	26.1		26.1				
Surface mines - reclaimed	26	26.2		26.2	26.2		26.2	
----- Landtypes below the escarpment -----								
<b>From Mid-Cumberland Plateau Guide (Smalley 1982)</b>								
Sandstone escarpment - north aspect		7.2		7.2	7.2	7.2		7.2
Sandstone escarpment - south aspect		7.3		7.3	7.3			7.3
Escarpment colluvial slopes - north aspect	16	16.1	16.1	16.1	16.1	16.1	16.1	16.1
Escarpment benches - north aspect	16	16.2	16.2	16.2	16.2	16.2	16.2	16.2
Escarpment colluvial slopes - south aspect	17	17.1	17.1	17.1	17.1	17.1	17.1	17.1
Escarpment benches - south aspect	17	17.2	17.2	17.2	17.2	17.2	17.2	17.2
Lower escarpment slopes - north aspect	18	18.1	18.1		18.1			18.1
Lower escarpment benches - north aspect	18	18.2	18.2		18.2			8.2
Lower escarpment slopes - south aspect	19	19.1	19.1		19.1			19.1
Lower escarpment benches - south aspect	19	19.2	19.2		19.2			19.2
Limestone spur ridges and knobs	20	28	28	28	28			28
Limestone rockland (outcrops) and shallow soils	20	20	20		20			20
Cherty slopes - north aspect		29		29	29			
Cherty slopes - south aspect		30		30	30			
Undifferentiated Sequatchie Valley		31		31	31			
Footslopes, terraces, streambottoms w/good drainage - in gorges		14.2			14.2	14.2	14.2	
Footslopes, terraces, streambottoms w/poor drainage - in gorges		15.2			15.2	15.2		
Terraces - Tennessee River gorge		24		24	24			
Sinkholes on lower escarpment slopes		25	25	25	25			
<b>From Eastern Highland Rim Guide (Smalley 1983)</b>								
Footslopes, terraces, streambottoms w/good drainage - in coves	21	21	21	21				21
----- Landtypes in the mountains -----								
<b>From Cumberland Mountains Guide (Smalley 1984)</b>								
Narrow shale ridges and convex upper slopes	27	32					32	
Broad shale ridges and convex upper slopes	28	33					33	
Upper mountain slopes - north aspect	24	34					34	
Upper mountain slopes - south aspect	25	35					35	
Colluvial mountain slopes and benches - north aspect		36					36	
Colluvial mountain slopes and benches - south aspect		37					37	
----- Miscellaneous landforms -----								
Water - streams, rivers, lakes, ponds - not associated w/surface mining		23.1	23.1	23.1	23.1	23.1	23.1	23.1
Water - lakes, ponds - associated w/surface mining		23.2			23.2			
Pits, dumps, quarries		27		27				

Period	Formation	State Forest				
P e n n s y l v a n i a n  P e r i o d	Graves Gap	F r a n k l i n & B l e d s o e  F o r e s t s	P r e n t i c e  C o o p e r  F o r e s t	S c o t t  F o r e s t	L o n e  M o u n t a i n  F o r e s t	P i c k e t  F o r e s t
	Indiana Bluff					
	Slatestone					
	Crooked Fork Group - 6 strata					
	Crab Orchard Mtn Group - 5 strata					
	Gizzard Group - 3 strata					
M i s s i s s i p p i a n  P e r i o d	Pennington					
	Bangor Limestone					
	Hartselle					
	Monteagle					
	St. Louis					
	Warsaw					
	Fort Payne					
	Chattanooga Shale					

Figure 2—Stratigraphy of the six state forests found on the Cumberland Plateau in Tennessee.

escarpment in dramatic waterfalls. Below the escarpment are steep talus slopes extending one-half to two-thirds of the distance down to the adjacent valleys. These slopes are strewn with boulders and punctuated with narrow benches. The lower escarpment slopes are dominated by thin limestone ledges and, in places, limestone rockland. These lower limestone slopes do not occur on BSF and are mostly covered by Nickajack Lake on PCSF. Lone Mountain rises 800 to 900 feet above the Plateau surface to an elevation of 2,530 feet and is flanked with steep talus slopes. Aspect is of minor significance on the undulating to rolling Plateau surface but is a significant site factor on the steep escarpment slopes and the sides of Lone Mountain.

### Vegetation

These SFs typify much of the Cumberland Plateau which has been subjected to indiscriminate cutting, burning, grazing, and clearing for subsistence farming. The current forests are a mosaic of stand conditions with seemingly fortuitous species composition. Generally, productivity is below potential due to poor stocking, a less than desirable mix of species,

and a high proportion of defective and low-vigor trees. Few stands exist that represent site potential. In general, forests on top of the plateau, on the south-facing upper escarpment slopes, and on south-facing slopes of Lone Mountain are composed of mixed red and white oaks (*Quercus* spp.). In upland drainages and depressions, sweetgum (*Liquidambar styraciflua* L.), red maple (*Acer rubrum* L.), white oak (*Quercus alba* L.), and yellow-poplar (*Liriodendron tuliperfira* L.) are common depending on soil drainage. A mixed mesophytic forest is common on the north-facing upper escarpment slopes, in shaded gorges like Bee Creek (BSF), and on north-facing slopes of Lone Mountain. A cedar (*Juniperus Virginia* L.)-mixed hardwood forest occupies the lower escarpment slopes. Preliminary estimates of productivity (site index and mean annual increment) and management limitations were derived from NRCS Woodland Suitability data for the soils common to each landtype or from experience.

### APPLICATION

Earlier research showed that the land classification system divided the PCSF landscape into distinct ecological units with relatively discreet plant communities (Arnold and others 1996). Additionally, the system grouped soils on the Catoosa Wildlife Management Area into landform units having relatively homogeneous chemical and physical properties (Hammer and others 1987).

Cleland and others (1997) listed ecosystem mapping, resource assessments, environmental analyses, watershed analyses, desired future conditions, resource management, and monitoring as uses of the NHFEU system. These uses also apply to Smalley's system. Currently, TDF is focusing on ecosystem delineation, resource assessment, desired future conditions, and resource management and monitoring. Much more data needs to be obtained before meaningful environmental and watershed analyses can be made.

### Current Uses

**Stand delineation**—Stands are delineated at the same scale as the landtype maps (1:24,000). Stands (silvicultural management units) have similar forest type and productivity and may range in size from 5 to 40 acres. Stand boundaries are typically roads and streams. Consequently, ridge landtypes (LTs-1 and 2) and upland hollows (LTs-14 and 15) are split. Some individual units of a landtype, conversely, may cover 50+ acres and, because of size restrictions, several stands may be defined with a single LT unit.

An immediate benefit of the landtype maps has been to reduce the time required to delineate stand boundaries. Heretofore stand delineation required several weeks of field work. With the availability of landtype maps, the task has been reduced to a few days (fig. 3).

**Management type determination**—Stands are characterized by a single forest type, often an association of two or more species where hardwoods are dominant. Because of past abuses, the current forest type may not be the desired management type. The ancillary information about desired species and estimated productivity for each LT will enable forest managers to formulate appropriate silvicultural strategies to achieve desired future stand conditions.



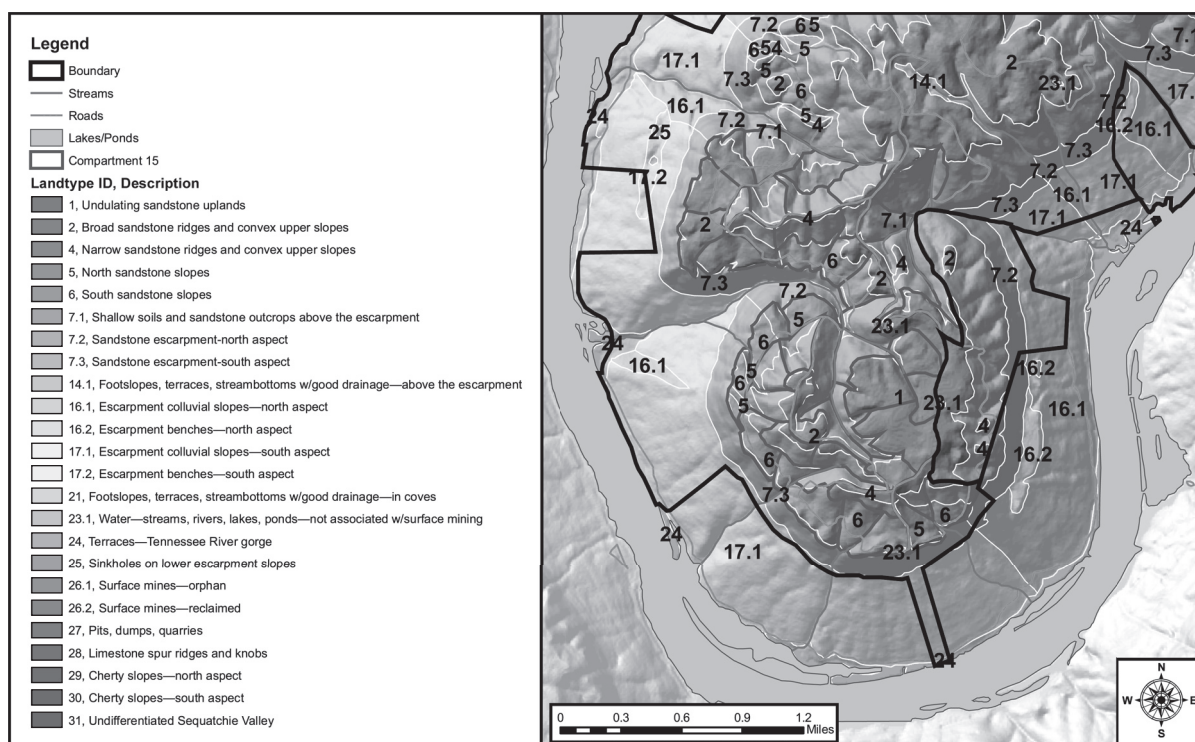


Figure 3—Stand delineation of compartment 15 on Prentice Cooper State Forest with the benefit of landtype mapping. Landtype and stand boundaries regularly coincide. Time to complete – a few days.

## Future Uses

**Forest Inventory**—The TDF is in the process of developing a state forest inventory. Assessment and monitoring of the resources on state forests is critical to making sound management decisions. An inventory and monitoring system based on the land classification system will provide better information at less cost. Since most stand and landtype boundaries coincide, species composition and productivity should be reasonably uniform within a stand. This uniformity will result in fewer inventory plots needed to achieve the same level of accuracy for timber volume and other forest characteristics compared to inventories not stratified by landtypes.

**Yield predictions**—We anticipate modeling future forest conditions by examining alternative management scenarios and the impact of disturbances such as insects, diseases, and fire. Plans include using the species desirability and productivity data for each LT as inputs to growth and yield prediction models. Results can be depicted using database and visualization software to view stands and landscapes through time enabling TDF to see to what extent alternative management strategies achieve stated objectives. This is the kind of information that TDF needs to promote current management decisions, the results of which may not be realized for several decades.

**Ecosystem delineation**—The concept of an ecosystem is subjective and dependent on scale and the organism(s) in question. An ecosystem can vary from a few square feet to hundreds and thousands of acres. Each SF is composed of several ecosystems at larger scales while at the same time each SF is part of a much larger ecosystem at a landscape scale. The land classification system provides a common

language and framework at multiple scales. Ecosystem delineation through the use of landtypes should also help in the locating rare, threatened and endangered (RTE) species and/or associated habitat(s) along with understanding how best to manage for their needs. Others have shown that landtypes or landtype associations can help locate suitable habitats for some RTE species (DeMeo 2001).

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